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REVIEW ARTICLE

Literacy Interventions for Students with Physical and Developmental Disabilities Who Use Aided AAC Devices: A Systematic Review

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Abstract This review evaluates research on literacy interventions for persons with physical and developmental disabilities who use aided augmentative and alternative communication (AAC). Electronic database searches were completed to identify studies published between 1989 and 2009. Eighteen studies (n=41 participants) were identified for inclusion in this review. Across studies a variety of instructional strategies were used to teach phonemic awareness, phonics, vocabulary, text comprehension, and participation in literacy activities. These strategies included direct instruction, scaffolding of communicative attempts, least-to-most prompting with time delay, writing workshop, and story mapping. The results of these studies indicated that systematic instruction including scaffolding, direct instruction, and least-to-most prompting with time delay may be the most effective strategies to teach literacy skills to this population. These results are discussed in relation to participant characteristics, the effectiveness of interventions, and the reported social validity of interventions. Suggestions for future research are discussed.

Keywords Literacy · Augmentative and alternative communication · Physical disabilities · Intellectual disabilities · Developmental disabilities

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Acquisition of literacy skills is a pivotal and highly desired outcome for all children, but perhaps even more so for students with physical and developmental disabilities (e.g., cerebral palsy, intellectual disability). Students with physical and developmental disabilities are at increased risk for delayed or no acquisition of literacy skills. For instance, as many as 90% of children with cerebral palsy cannot read or read below grade level, and even students with average IQ demonstrate below grade level reading abilities (Berninger and Gans 1986; Koppenhaver and Yoder 1992). Additionally, such students often have limited communication skills (Batshaw and Shapiro 2002; Matas et al. 1985; Yorkston et al. 1996) and may use AAC to communicate (Beukelman and Mirenda 2005). Students who are AAC users often have limited classroom discourse experience, impaired pragmatic skills, vocabulary delays, syntax difficulties, and demonstrate delays in phonology and the production of morphemes (Sturm and Clendon 2004).

Even so, the attainment of even basic literacy skills improves access to general education curriculum, provides a means to communicate ideas, thoughts, and opinions, improves functional life skills (e.g., reading medication labels, identifying restrooms, reading a bus schedule), and presents opportunities to engage in enjoyable leisure activities (e.g., reading a book or magazine, emailing a friend). Reading also provides opportunities to attain social and cultural power (e.g., filling out a job application, voting, paying bills) (Bishop et al. 1994; Copeland and Keefe 2007). The No Child Left Behind Act (NCLB, U.S. Department of Education 2002) and the Individuals with Disabilities Education Improvement Act of 2004 (IDEIA) (2004) mandate access to the general education curriculum for all students, including literacy instruction for students with physical and developmental disabilities. Rationale and support for literacy instruction for students with physical and developmental disabilities has likely never been stronger, but students still face significant barriers to accessing effective literacy instruction.

Past research on the literacy experiences of students with physical and developmental disabilities suggests that they have fewer opportunities to learn literacy than their typically developing peers (Beck 2002; Light and Kelford-Smith 1993; Kent-Walsh and Light 2003; Koppenhaver and Yoder 1993). Moreover, special education placements with a functional life skills focus and an institutional adherence to a philosophy of "reading readiness" (e.g., demonstrated understanding of phonemes, morphemes and rules of spoken language) may result in lowered expectations and decreased opportunities for students with disabilities to learn to read (Conners 1992; Kliewer and Biklen 2001; Zascavage and Keefe 2004). It is easy to imagine how these challenges may preclude student's achievement of even the most basic literacy skills. However, perhaps the most important barrier is a lack of information about effective literacy instruction for this population (Zascavage and Keefe).

Understanding three key bodies of knowledge may help to improve literacy instruction for students with physical and developmental disabilities who use AAC : (a) development of literacy skills including prerequisite skills students need to become successful readers, (b) the research base on effective literacy instruction, and (c) the unique needs of students with physical and developmental disabilities who use AAC. First, it is critical to understand what is required to develop successful literacy skills. The National Reading Panel commissioned by the National Institute for Child Health and Human Development (NICHD 2000) reported that phonemic

awareness, phonics, fluency, vocabulary, and comprehension were critical for students to develop into successful readers. They found phonemic awareness, or the ability to hear and manipulate the individual sounds in words, is among the strongest predictors of later reading performance (e.g., Share et al. 1984), and that explicitly teaching phonemic awareness resulted in strong positive outcomes for word reading and reading comprehension. Further, Wanzek and Vaughn (2007) reviewed the research on reading interventions finding that interventions that focused on both phonics instruction, or instruction in using letter sound correspondence to sound out and read words, and text reading had strong effects on reading outcomes including measures of phonemic awareness, word identification, word attack, spelling, reading fluency, vocabulary, and comprehension. Effective interventions were characterized by the delivery of explicit instruction in phonological awareness and phonics (e.g., Gunn et al. 2000, 2002; Torgesen et al. 1997, 1999) text reading (e.g., Jenkins et al. 2004; Morris et al. 2000; Santa and Hoien 1999), and comprehension strategies (e.g., Vadasy et al. 2002).

Finally, one might expect that those interventions effective for beginning or struggling readers may also be effective for this population, but students who are AAC users may present unique strengths and challenges. For instance, phonemic awareness tasks are typically auditory tasks that require a verbal response. The Putting Reading First publication suggested the following early phonemic awareness task to assess student's skill in identifying the initial phoneme of a word, 'Teacher: "What is the first sound in **van**?" Children: "The first sound in **van** is /v/."' (Eunice Kennedy Shriver, NICHD 2001)

Recent reviews have evaluated literacy interventions for children with autism (Whalon et al. 2009), and for students with significant cognitive disabilities (e.g., moderate to severe intellectual disability) (Browder et al. 2006, 2009). These previous reviews have included intervention studies that included participants with physical and developmental disabilities that used aided AAC, but the purpose of these reviews was not on identifying effective literacy instruction for aided AAC users. For instance, Browder et al. (2006) did not review studies including students who were nonverbal (and likely to use aided AAC) and Browder et al. (2009) reviewed studies using time delay to teach literacy to students with severe developmental disabilities. Additionally, Hetzroni (2004) provided a descriptive review of literature on emergent literacy and AAC use, but this review was not systematic, and did not evaluate the effectiveness of reviewed literacy interventions, or focus on aided AAC users. We are not aware of any literature reviews that have focused specifically on literacy instruction for students with physical and developmental disabilities who use AAC.

To facilitate evidence-based practice in this important area, the present paper provides a systematic review of literacy interventions conducted for children and youth with physical and developmental disabilities who use aided AAC. This review describes characteristics of these studies (e.g., participants, research designs, intervention goals and procedures), evaluates intervention outcomes, and appraises the certainty of the evidence for the existing studies. The primary purpose of this review is to guide and inform practitioners in evidence-based literacy instruction for students with physical and developmental disabilities who use aided AAC. An additional purpose is to identify gaps in existing literature to stimulate future research efforts aimed at developing new and more effective intervention strategies.

Method

Inclusion and Exclusion Criteria

We included studies in this review based on four criteria. First, each study included at least one participant less than 21 years with a diagnosis of an orthopedic impairment (e.g., cerebral palsy) or a developmental disability (e.g., intellectual disability) who used an aided AAC device to communicate. Aided AAC was defined as the use of an external device for message production (Lloyd and Fuller 1986). Examples of aided AAC are picture communication boards, and voice output communication aides (VOCA). Sign language is an example of unaided AAC. Participants who were taught to use an aided AAC device over the course of the study were also included (Bellon-Harn and Harn 2008; Koppenhaver et al. 2001a, b). Second, our search focused on studies published in a peer-reviewed journal over a 20-year period between 1989 and 2009. This time period was selected to focus on the most recent and relevant research. Third, each included study implemented a recognized research design (e.g., single-subject design). Descriptive case studies were not included (e.g., Erickson et al. 1997). Finally, each included study described instruction aimed at increasing or improving the participant's literacy or emergent literacy skills including phonemic awareness, phonics, oral reading fluency, vocabulary related to texts, text comprehension, or participation in literacy activities (e.g., turn taking during storybook reading, creating a fictional narrative). Studies solely targeting pragmatic communication outside of literacy activities such as commenting during circle time (Snyder et al. 1993) or sharing information during social interactions (Myers 2007), were excluded. Studies aimed at improving writing skills were also excluded (e.g., Morris et al. 1992). Such studies were excluded because they focused more on communication than literacy. Additionally, studies aimed at improving the literacy skills of children with an autism spectrum disorder were excluded (for a recent review of these studies, see Whalon et al. 2009). Finally, studies focused only on assessment or description of literacy skills were not included (e.g., Hjelmquist et al. 1994).

Search Procedures

Electronic searches were completed using ERIC, PsychINFO, and MEDLINE. The search was limited to English-language, peer-reviewed studies published between the years of 1989 and 2009. On each database, each of the following terms "literacy", "reading,", "phonics", "word recognition", "vocabulary", "comprehension" were individually paired with the term "augmentative" and inserted into the *Keywords* fields. This initial search yielded a sample of 373 studies. The abstracts of the 373 studies were reviewed using the aforementioned criteria to identify studies for inclusion. The reference sections of included studies were examined for possible additions to the review. Additionally, a hand search, covering 2004–2009, was then completed for the journal publishing the majority of the included studies (i.e., *Augmentative and Alternative Communication)* for possible additions to the review. Finally, the first and last names of first authors of included studies were inserted into the *Keywords* field and searched by *Author* to identify possible additions to the review. A total of 18 studies (n=41 participants) were identified that met inclusion criteria.

Data Extraction

For each evaluated study, Table 1 describes the following five variables: (a) participant characteristics, (b) goal(s) of intervention, (c) intervention procedures, (d) results of the intervention, and (e) certainty of evidence. The results of each intervention were reported based on the amount of improvement in the targeted literacy skill(s) following introduction of the intervention. Additionally, for those studies utilizing single subject designs, findings were summarized by calculating percentage of non-overlapping data (*PND*; Scruggs et al. 1987). Only data points in baseline and intervention were used to calculate PND, because some interventions did not include a maintenance phase.

We utilized measures of certainty of evidence to assess the quality of evidence across the reviewed studies (Millar et al. 2006; Schlosser and Sigafoos 2007). Certainty of evidence was obtained by evaluating each study's research design and other methodological variables (i.e., effect of the intervention, inter rater reliability, and operational definition of dependent and independent variables). Certainty of evidence was described as either inconclusive or conclusive Millar et al. (2006). Studies were defined as conclusive if they met five criteria: (a) included an experimental design (e.g., multiple baseline, ABAB, alternating treatment), (b) visual inspection of data trends within and across experimental phases demonstrated clinically significant improvement in targeted literacy skills for at least one participant (Kennedy 2005), (c) obtained inter rater reliability measures (i.e., interobserver agreement, IOA) for at least 20% of experimental sessions that equaled or exceeded 80% agreement, and (d) operationally defined dependent and independent variables and described instructional procedures with sufficient detail for replication. Studies were defined as inconclusive if they failed to meet one or more of these criteria.

Inter-rater Agreement

The first, third, and fourth authors independently implemented the search procedures and identified relevant studies based on the inclusion criteria. Discrepancies regarding inclusion decisions were discussed and a final determination regarding inclusion/exclusion was made according to the inclusion criteria. The first author developed initial written summaries of the 18 included studies. The fifth and sixth authors then independently assessed each study's summary for accuracy. They were asked to read the study, its summary, and to complete a checklist regarding each summary's accuracy. The checklist included the following questions: (a) Is this an accurate description of the participants?, (b) Is this an accurate description of the research design?, (c) Is this an accurate description of the goal(s) of the intervention?, (d) Is this an accurate descriptions of the procedures used in the study?, (e) Is this an accurate description of the results?, and (f) Is this an accurate summary of the study's certainty of evidence? In instances where the co-authors found the study summary to be inaccurate or incomplete, they were asked to edit the summary accordingly. Resulting summaries were used to create Table 1.

Inter-rater agreement on data extraction was obtained by dividing the total number of items on which there could be agreement (i.e., 18 studies with six questions for each study) by the number of agreements. Inter-rater agreement was obtained for 99% of items.

Table 1 Studies according to categories with participant characteristics, goal(s) of intervention, intervention procedures, results, and certainty of evidence

Citation	Participant characteristics	Goal(s)	Intervention procedures	Results and certainty of evidence
Bellon-Harn and Harn (2008)	One female, 6 years old, moderate-severe intellectual disability and legal blindness	Increase the number of vocal and aided utterances, mean length of vocal utterances, correct responses to *wh*-questions, and child initiations. Decrease off topic utterances	*Scaffolding:* Compared effects of RSR[a] with scaffolding speech to RSR[a] with scaffolding use of SGD[b]. Therapist first read storybook, then discussed each page, asking *wh*-questions, providing language expansions, modeling correct word/phrase verbally (and use of SGD[b] in AAC[c] condition)	*Results:* Communicative responses and child initiations increased with the introduction of both RSR[a] and AAC[c] conditions. However, the AAC[c] condition resulted in the greatest increase in communicative responses (oral-only+AAC[c] responses) Mean length of utterance did not change. Phonological complexity of communication was also improved with the child using more CVC[d] following intervention *Certainty of Evidence:* Conclusive
Binger et al. (2008)	One male, 4 years old, Severe motor speech disorder. one female, 3 years old, suspected VCFS[e], childhood apraxia of speech. one female, 2 years old, subpalatel cleft	Increase spontaneous and imitated multi-symbol utterances in response to *wh*-questions, and multi-symbol messages	*Scaffolding*: Parents read a page and modeled two-symbol communication, asking *wh*-questions and implementing 5 s constant time delay between prompts	*Results:* All of the participants used multi-symbol messages with greater frequency following intervention (*M* PND[f] = 100%) and generalized use of multi-symbol messages to novel storybooks. Target skills were maintained at 2, 4, and 8 weeks for two participants and at 2 weeks for the third participant *Certainty of Evidence:* Conclusive
Browder et al. (2008)	One female, 7 years old with severe-profound delays, spina bifida, cranial shunts, hydrocephalus, and seizures. one male, 7 years old, profound delays, cerebral palsy, seizures, and scoliosis. one male, 10 years old, profound delays, cytomegalovirus, cerebral palsy, miscrocephaly, seizure disorder, and hemiplegia	Increase child's ability to choose a book to read, their attention to adult reading book and concrete materials used during the story. Improve child's ability to make a prediction, react to their own name, complete intraverbals, react to surprise element in story, and to choose whether to read story again	*Universal design*: Material adaptations (e.g., using a light box behind concrete objects), instructional adaptations (e.g., increasing time delay between prompts), physical "warm up" *Least-to-most prompting with constant time delay*: LTM[g] prompting with 5 s constant time delay during story time	*Results:* All three participants increased independent responding during shared storybook reading (*M* PND[f] = 100%) *Certainty of Evidence*: Conclusive
Fallon et al. (2004)	One male, 11 years old, intellectual disability. one male, 14 years old, intellectual disability. one male, 9 years old, Down syndrome	Improve student's ability to match single sounds to the initial sounds of words, and to telescope sounds onto words. Increase the number of VC[h] and CVC[d] sight words read correctly	*Direct instruction*: Student presented with four picture symbols, written words and verbal labels. Three pictures were foils and one was the correct response. Student was asked to choose picture of the word that	*Results:* Each of the three participants improved in their ability to read single targeted VC[h] and CVC[d] words. (*M* PND[f] = 96% range, 88–100%), but demonstrated less improvement in reading

		by student during reading of book	started with the phoneme. For single-word reading, interventionist read word. Student was asked to select correct picture of the read word. Both conditions used modeling, prompting, and corrective feedback	target words in book contexts with two of three participants demonstrating generalization to book contexts (*M* PND[f] = 83% range, 50–100%). However, generalization was not assessed during baseline assessment *Certainty of Evidence*: Conclusive
Hanser and Erickson (2007)	One female, 13 years old, cerebral palsy. one male, 13 years old, moderate intellectual disability, cerebral palsy. one male, 7 years old, cerebral palsy	Improve word identification, icon sequencing, expressive communication, word generation, and developmental spelling	*Literacy Through Unity: Word Study Curriculum*: Using a reading curriculum designed specifically for use with an AAC[c] software (Unity), students were presented with 75 lessons, each consisting of: word wall, making words with icons, and making words with letters	*Results:* Descriptive statistics suggested improvements for all participants in word identification, spelling, and communication, but visual analysis of data suggests highly variable student performance during baseline, intervention, and maintenance phases (*M* PND[f] for number of icon sequences selected=9 range, 0–42%; *M* PND[f] for frequency of letters selected=10 range, 0–17%) *Certainty of Evidence*: Inconclusive, due to non-concurrent multiple baseline across participants
Johnston et al. (2009)	One male, 5 years old, cerebral palsy and severe developmental delay	Improve child's ability to correctly identify targeted letters and spell words consisting of CVC[d] combinations	*Direct instruction*: For teaching letter-sound correspondence, teacher delivered scripted instruction. Model-prompt-check prompts with 5 s constant time delay, corrective feedback and access to preferred item contingent on correct responses	*Results:* Student's ability to correctly identify targeted letter and spell CVC[d] words improved following instruction (*M* PND[f] for number of correct identification of letters=98% range, 88–100%; *M* PND[f] for number of correct spelling of CVC[d] combinations=100%) *Certainty of Evidence:* Conclusive
Koppenhaver et al. (2001a)	Six females, ages 3–7 years old, Rett syndrome	Increase the frequency and range of symbolic communication, labels, and comments	*I. Non-dominant hand splints:* Children wore hand splint during storybook reading with their mothers	*Results:* Each of the six children demonstrated small improvements in their use of symbolic communication during reading of familiar and unfamiliar storybooks upon introduction of hand splints, but demonstrated larger increases upon introduction of AAC[c] devices and parent-implemented scaffolding and LTM[g] prompting
			II. Introduction of AAC[c] devices: Mothers provided with AAC[c] d	*Certainty of Evidence*: Inconclusive, due to ABCD research design

Table 1 (continued)

Citation	Participant characteristics	Goal(s)	Intervention procedures	Results and certainty of evidence
			evices/picture communication symbols *III. Scaffolding and LTM[g] prompting with time delay:* Mothers prompted AAC[c] use through *wh*-questions, modeled AAC[c] use and LTM[g] prompting with 10–30 s time delay	
Koppenhaver et al. (2001b)	Four females, ages 3–7 years old, Rett syndrome	Increase the frequency and range of symbolic communication, labels, and comments	*I. Non-dominant hand splints:* Same procedures as described in Koppenhaver et al. (2001a)	*Results:* Splinting had no effect on participant communication. Each participant's communication attempts during reading of familiar and unfamiliar storybooks increased upon introduction of AAC[c] devices and parent-implemented scaffolding and LTM[g] prompting with time delay. For three of four participants, the third experimental phase resulted in the highest rates of labeling and commenting. For the fourth participant, labeling and commenting decreased during the third phase
			II. Introduction of AAC devices: Same procedures as described in Koppenhaver et al. (2001a)	*Certainty of Evidence:* Inconclusive due to ABCD research design
			III. Scaffolding LTM[g] prompting with time delay: Same procedures as described in Koppenhaver et al. (2001a)	
Mathisen et al. (2009)	One female, 3 years old, cerebral palsy, congenital heart disease, microcephaly	Improve child's pragmatic communication, phonological awareness, and print awareness	*Storybook reading with scaffolding:* Student provided with SGD[b] (Vanguard II). Each MINSPEAK icon was targeted with core and fringe vocabulary during: storybook reading, structured play activities, and free play. Verbal prompts given to assist student's identification of target words on SGD[b]	*Results:* Child's receptive language improved, her use of multi-word utterances increased, and she demonstrated greater awareness of environmental print, book knowledge, and early writing concepts. Improvements in phonological awareness were inconclusive *Certainty of Evidence*: Inconclusive due to AB design

Millar et al. (2004)	One female, 7 years old, cerebral palsy, cystic fibrosis, congenital amputation of left hand. one female, 10 years old, Cerebral palsy. one male, 10 years old, alternating hemiplegia	Improve child's ability to correctly select the initial letters of orally presented words, and to correctly select letters that correspond to letter sounds	*I. direct instruction*: For letter-sound instruction, interventionist vocalized a letter sound or word, and asked student to select corresponding letter/initial letter on keyboard using MTL[i] prompting	*Results:* Two of three participants improved in their ability to select the initial letters of orally presented words (*M* PND[f] = 100%) and to correctly select letters corresponding to letter sounds (*M* PND[f] = 78% range, 50–100%). The same two participants also demonstrated generalization of targeted skills to the identification of initial letters of novel words and one of the two participants was able to select the initial letter of words without the interventionist providing an oral model. However, one participant showed little progress on targeted skills until instruction was adapted and did not meet criterion performance for all targeted letters/sounds
			II. *Writing workshop*: Student provided four picture prompts. Interventionist read each word and student was asked to write a personal story. Interventionist modeled the selection of initial letters from the picture prompts and created a story by linking words typed by student	*Certainty of Evidence: Conclusive,* for two participants. *Inconclusive,* for one participant due to lack of clinically significant improvement upon introduction of intervention
Ratcliff and Little (1996)	One male, 6 years old, cerebral palsy	Improve sight-word recognition	*Barrier task*: Student read sentence and used pictures to create a fitting scene. The interventionist created picture scene behind a barrier, which was used as corrective feedback. Student prompted to find specific sight words on AAC[c] device. Interventionist repeated the word, pointed out the letters, and created a sentence using the word. The student was asked to choose a sentence and use his AAC[c] device to direct the interventionist to use pictures to represent the sentence	*Results:* Participant learned all targeted sight words and some additional novel sight words. His letter recognition skills improved for 9 of 26 letters *Certainty of Evidence: Inconclusive,* AB design
Rosa-Lugo and Kent-Walsh (2008)	One female, 6 years old, cystic hygroma. one male, 6 years old, developmental delay	Increase the number of communicative turns and understanding of novel semantic concepts	*Scaffolding*: Parents implemented multicomponent intervention during storybook reading. Parents increased their responsivity to child's communicative attempts,	*Results:* Each participant demonstrated increased communicative turns and expression of novel semantic concepts during reading of

Table 1 (continued)

Citation	Participant characteristics	Goal(s)	Intervention procedures	Results and certainty of evidence
			used open ended questions, provided expectant delays and modeled use of AAC[c] device	familiar and unfamiliar storybooks. (*M* PND[f] =100%) *Certainty of Evidence:* Conclusive
Soto et al. (2007)	One female, 8 years old, muscular atropy	Improve narrative skills	*Repeated storybook reading with scaffolding and story mapping*: Teacher read story aloud and asked student to retell story using graphic story map using open-ended questions as guidance	*Results:* The student began to use sentences for narration that included increased use of verbs, independent and subordinate clauses. Narratives demonstrated improved grammatical complexity and more diverse vocabulary usage
			Personal storytelling: Student was given a fill-in-the blank picture symbol story to prompt sharing personal experiences	*Certainty of Evidence:* Inconclusive, due to AB design
			Fictional storytelling: Student was provided with picture cards representing story elements and was asked to choose cards and create a verbal story	
Soto and Dukhovny (2008)	One female, 7 years old, Perisylvian syndrome and mild visual impairment	Increase the frequency and range of words used, multiword utterances, and story constituents	*Shared reading with scaffolding:* Pre-reading: Interventionist programmed five target words and created and modeled sentences using target words on AAC[c] device. Shared reading: Interventionist read book aloud and asked comprehension questions. Interventionist used cloze procedure, offered communication choices and used gestural and verbal prompts. Post reading: Interventionist read story aloud again emphasizing target words. Student was asked open-ended questions to prompt use of target words. Interventionist modeled summary sentences on AAC[c] device and asked student to retell story	*Results:* The participant's use of multi-word utterances and the number of different words she used increased (*M* PND[f] = 100%). The participant's use of story constituents did not improve significantly (*M* PND[f] = 67%) *Certainty of Evidence*: Inconclusive, due to Multiple probe ABC design
Soto et al. (2008)	One female, 12 years old, cerebral palsy	Increase the number of different words, clauses, and story elements used by the child	*Repeated storybook reading with scaffolding and story mapping*: Student was read a story and asked to retell story using AAC[c]	*Results:* The participant's use of different words (*M* PND[f] = 90%, range 80–100%), clauses (*M* PND[f] = 100%), and story

			device. Sentence creation prompted using cloze strategy. A graphic story map and open-ended questions were used to support student's retelling of the story	elements (*M* PND[f] = 100%) increased during the creation of both personal and fictional narratives
			Fictional storytelling: Student was provided with Never Ending Stories picture cards representing story elements and asked to choose cards and create a story	*Certainty of Evidence:* Inconclusive, due to Multiple probe ABC design
			Personal storytelling: Student was given fill-in-the blank story to prompt sharing of personal information and experiences	
Trudeau et al. (2003)	One female, 5 years old, severe speech and physical impairment	Improve participation during group storybook reading	*Shared storybook reading with aided language stimulation and scaffolding in group setting:* Parent–child dyads participated in group storybook reading. Physical props, picture communication boards, choice boards, and SGD[b] were available. The interventionist pointed to relevant picture symbols, modeled the use of AAC[c], and used LTM[g] prompting to elicit communicative responses. Following book reading, children participated in a related thematic activity	*Results:* Both participants used a greater variety of communication modes, communicated more frequently with adapted books. One participant's participation (e.g., acting on props, choral reading) during group storybook reading improved, but decreased for the other participant *Certainty of Evidence:* Inconclusive, due to AB design
Truxler and O'Keefe (2007)	Four children, ages 8–9 years old, cerebral palsy and intellectual disability	I. Improve child's ability to match spoken letter name or letter sound to the associated picture of the word beginning with that letter. II. Improve child's ability to match spoken syllable or word read aloud to the correct written syllable or word	I. *Direct instruction*: Interventionist read a storybook to student that targeted a single letter/sound. Students answered comprehension questions by pointing to picture symbols. Interventionist reread story and pointed to targeted letter/sound in words. Student asked to find target letter on keyboard	*Results:* One participant improved her phoeneme awareness, ability to match letter/sounds, but did not improve in her ability to generalize skills to nonwords. The other three participants did not demonstrate criterion level accuracy in targeted skills (*M* PND[f] for percentage of correct responding in Experiment I = 73% range, 18–100%; *M* PND[f] for percentage of correct responding in Experiment II = 61% range, 0–92%)
			II. *Direct instruction*: Interventionist blended letter/sounds into VC syllables and CVC[d] words by elongating and iterating sounds, pointing to cards with written target letters, and sliding the letter cards together as the sounds were blended. Student asked	*Certainty of Evidence:* Inconclusive due to, Non-concurrent multiple baseline across participants design

Table 1 (continued)

Citation	Participant characteristics	Goal(s)	Intervention procedures	Results and certainty of evidence
			to identify VC[h] syllable from two choices and spell it on keyboard as interventionist vocalized letter sounds and printed on paper. Interventionist read a sentence containing a word with the targeted VC[h] syllable combination. Once child had received instruction for all initial letters/ sounds, CVC[d] syllables were taught using the same procedures	
Wilkinson and Albert (2001)	One female, 14 years old, Down syndrome and intellectual disability	Increase the number of sight words correctly identified	*Computer assisted fast mapping vocabulary instruction*: Set of pictures presented in concurrent introduction on touch sensitive computer screen. Student asked to identify the picture corresponding to the spoken word. Computer generated praise according to a variable ratio schedule of reinforcement	*Results:* Participant learned all targeted sight words and demonstrated significant improvement from baseline (one-tailed *t*-test, $t(8)=9.90$, $p=.05$) *Certainty of Evidence*: Inconclusive due to AB design

[a] Repeated storybook reading

[b] Speech generating device

[c] Augmentative and alternative communication

[d] Consonant-vowel-consonant

[e] Velo-cardio-facial syndrome

[f] Percentage of all non-overlapping data

[g] Least-to-most

[h] Vowel-consonant

[i] Most-to-least

The remainder of this paper is organized into two sections. The results section presents an overview of the participants, the research designs used to evaluate interventions, the goals of interventions, intervention procedures and outcomes, and certainty of evidence. All studies are summarized in Table 1. The discussion section evaluates the outcomes of the 18 studies in regard to (a) participant characteristics, (b) the types of literacy skills that researchers aimed to improve, (c) the effectiveness of the interventions, and (e) the social validity of interventions and offers suggestions for future research.

Results

Participants

Each of the 18 studies included in this review reported the age, diagnosis, and communication skills of participants. With one exception, the gender of participants was reported (Truxler and O'Keefe 2007). Although the number of participants included in each study varied from one participant to six participants, the majority of studies included either one or three participants (n=12 studies). Some studies included additional participants that did not meet inclusion criteria, that is they included a participant without a diagnosis of a physical or developmental disability (Trudeau et al. 2003), included a participant with a diagnosis of autism spectrum disorder (Johnston et al. 2009; Wilkinson and Albert 2001), or included participants that did not use an aided AAC device (Fallon et al. 2004). Twenty-five of the participants were female (61%) and 12 (29%) were male. Participants ranged from 2 to 14 years, but the majority (61%) of participants were between 3 and 7 years. Twenty-seven percent of the participants were between 8 and 12 years, and a minority (10%) of the participants were 13 years or older.

The majority (66%) of participants were described as having either multiple disabilities (e.g., cerebral palsy and severe developmental delay) or a genetic syndrome (i.e., Down syndrome, Rett syndrome, Perisylvian syndrome) commonly associated with intellectual disability. Those studies reporting the severity of intellectual disability more frequently reported participant diagnoses of severe-profound intellectual disabilities (n=4) than moderate or moderate-severe intellectual disabilities (n=2). Other reported disabilities included cerebral palsy (n=5), intellectual disability (n=2), developmental delay (n=1), severe motor speech disorder (n=1), cleft palate (n=1), cystic hygroma (n=1), alternating hemiplegia (n=1), and muscular atropy (n=1).

Studies reported that the participants communicated using a variety of modalities prior to intervention, but most (n=18) were reported to communicate using a variety of different communication modalities (e.g., vocalizations, limited repertoire of intelligible words, gestures, sign language, speech generating device, picture communication board). Other participants (n=10) were reported to primarily communicate using a SGD or picture communication symbols. Participant descriptions suggest that the majority of participants demonstrated intentional communication behaviors. However, three participants with severe-profound and multiple disabilities were reported to demonstrate a restricted repertoire of

communication behaviors (e.g., limited to crying when uncomfortable and smiling when happy) (Browder et al. 2008). Similarly, participants with Rett syndrome communicated primarily using idiosyncratic vocalizations and gestures (Koppenhaver et al. 2001a, b). Such communication behaviors may suggest prelinguistic communication. One participant primarily communicated verbally using one–three word utterances, but was taught to use a voice output communication aid (VOCA) during intervention (Bellon-Harn and Harn 2008).

Additionally, the majority of studies (n=13) reported the pre-baseline literacy skills of participants. A few participants were unresponsive during storybook reading (n=3 participants) or demonstrated limited to no basic print awareness (n = one participant). However, the majority of participants demonstrated basic literacy skills such as the ability to: (a) listen to stories and answer basic comprehension questions (n=5 participants), (b) identify letters (n=4 participants) and basic vocabulary (n=6 participants), and (c) demonstrate letter sound correspondences (n=5 participants). Two participants were emerging readers capable of decoding text (Soto et al. 2007; Soto and Dukhovny 2008).

Research Designs

The majority (61%) of studies reported using non-experimental research designs to evaluate intervention effects. The most commonly utilized non-experimental research design was the AB design (n=5) (Mathisen et al. 2009; Ratcliff and Little 1996; Soto et al. 2007; Trudeau et al. 2003; Wilkenson and Albert 2001). Four additional studies utilized a variation of the AB design (i.e., ABCD, multiple probe ABC) (Koppenhaver et al. 2001a, b; Soto and Dukhovny 2008; Soto et al. 2008). Two studies used non-concurrent multiple baseline designs (Hanser and Erickson 2007; Truxler and O'Keefe 2007). Thirty-nine percent of studies evaluated intervention effects using a single-subject design that provided a degree of experimental control. Four studies implemented multiple baseline across participants or behaviors designs (Browder et al. 2008; Johnston et al. 2009; Millar et al. 2004; Rosa-Lugo and Kent-Walsh 2008). Other studies implemented multiple probe across participants designs or multielement designs (Bellon-Harn and Harn 2008; Binger et al. 2008; Fallon et al. 2004).

Goals of Interventions

Four studies targeted single literacy skills (i.e., sight word vocabulary, participation during book reading, narrative skills), but the majority of studies aimed to improve multiple target behaviors (e.g., pragmatic communication, phonological awareness, and print awareness). Nine studies aimed to increase the frequency, variety, or complexity of AAC messages during literacy activities (Bellon-Harn and Harn 2008; Binger et al. 2008; Browder et al. 2008; Koppenhaver et al. 2001a, b; Mathisen et al. 2009; Rosa-Lugo and Kent-Walsh 2008; Soto and Dukhovny 2008; Soto et al. 2008). Two of these nine studies assessed the use of AAC devices to answer *wh*-questions (Bellon-Harn and Harn 2008; Binger et al. 2008). Letter-sound correspondence was assessed in four studies (Fallon et al. 2004; Hanser and Erickson 2007; Truxler and O'Keefe 2007; Millar et al. 2004). The overall goal of

Browder et al. was to increase student participation during storybook reading. Other targeted skills included letter identification and spelling (Johnston et al. 2009), decoding (Fallon et al. 2004), spelling, and print awareness (Mathisen et al. 2009).

Intervention Procedures

A variety of strategies were used to teach targeted literacy skills. Although the majority (56%) of studies delivered multi-component interventions, some common instructional strategies were reported across interventions. Nine studies used language scaffolding procedures during storybook reading (Bellon-Harn and Harn 2008; Binger et al. 2008; Koppenhaver et al. 2001a, b; Rosa-Lugo and Kent-Walsh 2008; Soto et al. 2007; Soto and Dukhovny 2008; Soto et al. 2008; Trudeau et al. 2003). Speech and language therapists commonly use scaffolding procedures to elicit more frequent and complex child communication. Scaffolding procedures include repeating child utterances (conversational recasts), expanding child utterances (expansions), and asking *wh*-questions to elicit communication (Camrata and Nelson 2006). Systematic prompting hierarchies (i.e., direct instruction and least to most prompting) were used in eight studies (Browder et al. 2008; Fallon et al. 2004; Johnston et al. 2009; Koppenhaver et al. 2001a, b; Millar et al. 2004; Trudeau et al. 2003; Truxler and O'Keefe 2007).

Other intervention strategies, often used in conjunction with the aforementioned procedures, included barrier task, computer assisted fast mapping vocabulary instruction, fill-in-the-blank stories, picture card prompts, story mapping, introduction of a package of AAC devices and accessories, non-dominant hand splints, using universal design principles to modify instructional procedures, writing workshop, and a reading curriculum (i.e., *Literacy Through Unity: Word Study Curriculum)* specifically designed for use with AAC devices (see Table 1).

Interventions were primarily (67%) delivered during storybook reading or repeated storybook reading (Bellon-Harn and Harn 2008; Binger et al. 2008; Browder et al. 2008; Koppenhaver et al. 2001a, b; Mathisen et al. 2009; Rosa-Lugo and Kent-Walsh 2008; Soto et al. 2007, 2008; Soto and Dukhovny 2008; Truxler and O'Keefe 2007; Trudeau et al. 2003). Moreover, the majority (89%) of interventions were delivered in one-to-one instruction. Only two studies implemented instruction during small group activities (Johnson et al. 2009; Trudeau et al. 2003).

Interventionists most commonly included mothers (n=15 participants), fathers (n = one participant), or researchers (n=14 participants). Other studies had special education teachers (n = two participants), AAC specialists (n = three participants), a SLP (n = one participant), or an educational assistant (n = one participant) deliver instruction. One study did not specify the type of clinician who delivered instruction (Bellon-Harn and Harn 2008). Additionally, one study utilized computer assisted instruction (Wilkinson and Albert 2001).

Interventions were delivered in a variety of settings including family homes (n= 13 participants), segregated special education classrooms (n = five participants), separate rooms outside of classrooms (n = eight participants), and an inclusive classroom (n = one participant). Mathisen et al. (2009) delivered intervention to a participant in both home and school settings. Two additional studies reported implementing intervention procedures in an unspecified school setting (Soto et al.

2007; Soto and Dukhovny 2008). Bellon-Harn and Harn (2008) delivered intervention procedures in an outpatient speech and language clinic. Instructional settings were not described for four studies (Binger et al. 2008; Fallon et al. 2004; Ratcliff and Little 1996; Wilkinson and Albert 2001).

Individual instructional sessions lasted between 10 min and 90 min, with a number of studies (n=6) reporting individual instructional times of 45 min or less. Instruction was delivered between one and five times each week. The total amount of instruction provided to a participant ranged from 100 min to 30 h. Most studies (n=6) reported total instruction time to be 10.5 h or less, but four studies reported total instruction time to be 18 or more hours. Seven studies did not report the length of instructional sessions (Bellon-Harn and Harn 2008; Fallon et al. 2004; Johnston et al. 2009; Koppenhaver et al. 2001a, b; Rosa-Lugo and Kent-Walsh 2008; Wilkinson and Albert 2001).

Outcomes

In terms of improving literacy skills, outcomes across studies were mostly positive. The mean PND across studies was 81% (range, 9–100%; mode = 100%). Each of the 11 studies yielding mean PND scores of 90% or higher utilized some form of systematic instruction (i.e., scaffolding, least to most prompting with time delay, direct instruction). For seven studies, PND could not be calculated due to the research design (e.g., multielement) or to the way that data was reported (e.g., as group means) (Bellon-Harn and Harn 2008; Koppenhaver et al. 2001a, b; Mathisen et al. 2009; Ratcliff and Little 1996; Soto et al. 2007; Trudeau et al. 2003). For four of these seven studies, visual analysis of data trend and level suggest these interventions were effective (Bellon-Harn and Harn; Koppenhaver et al. 2001a, b; Trudeau et al. 2003) Additionally, Wilkinson and Albert (2001) reported positive results using a one-tailed t-test ($t(8)$= 9.90, p=.05). For studies that did not allow for visual analysis of data, positive results were reported, but should be carefully regarded due to methodological limitations (Mathisen et al. 2009; Ratcliff and Little 1996; Soto et al. 2007). For example, Mathisen et al. (2009) reported that post-intervention assessments demonstrated that the participant's receptive language improved, her use of multi-word utterances increased, and that she demonstrated greater print awareness, but improvements in phonological awareness were inconclusive. However, Mathisen et al. (2009) used an AB design and relied on pre- and post-intervention assessments administered by the researcher in an unblinded fashion to determine intervention effects.

Eight studies collected maintenance data and reported positive treatment effects following intervention from 3 days to 8 weeks (Binger et al. 2008; Fallon et al. 2004; Hanser and Erickson 2007; Johnston et al. 2009; Millar et al. 2004; Rosa-Lugo and Kent-Walsh 2008; Soto and Dukhovny 2008; Truxler and O'Keefe 2007). No study reported failure of skills to maintain.

Four studies assessed generalization of targeted literacy skills to novel books (Binger et al. 2008; Browder et al. 2008; Koppenhaver et al. 2001a, b). Seven additional studies assessed generalization of literacy skills to novel words, settings, people, and prompts (Fallon et al. 2004; Millar et al. 2004; Rosa-Lugo and Kent-Walsh 2008; Truxler and O'Keefe 2007; Hanser and Erickson 2007; Soto and Dukhovny 2008; Soto et al. 2007). One study assessed generalization of letter identification to a different keyboard (Johnston et al. 2009).

Additionally, six studies reported assessing the social validity of intervention procedures. Social validity was assessed by evaluating the results of questionnaires completed by a variety of educational staff (i.e., general and special educators, SLPs), and parents of participating children (Browder et al. 2008; Johnston et al. 2009; Rosa-Lugo and Kent-Walsh 2008; Soto and Dukhovny 2008; Soto et al. 2008). Two studies conducted pre-intervention focus groups with various stakeholders to identify relevant themes regarding the acceptability of intervention procedures (Binger et al. 2008; Rosa-Lugo and Kent-Walsh).

Certainty of Evidence

All the reviewed studies utilized single-subject research designs. Thirty-nine percent of studies used experimental single subject designs (e.g., multiple baseline across participants or behaviors) and 61% of studies utilized non-experimental single subject designs (e.g., AB). The certainty of evidence in each study was classified as conclusive or inconclusive. The certainty of evidence was rated as inconclusive for 12 of the reviewed studies and as conclusive for six of the reviewed studies (see Table 1). In 11 of the 12 inconclusive cases a non-experimental design (e.g., AB) was utilized. In Millar et al. (2004) the certainty of evidence for an intervention effect was rated as conclusive for two participants and inconclusive for two participants due to visual analysis of data that did not indicate significant improvement over baseline assessment.

Discussion

This paper reviewed 18 studies that examined instructional strategies to teach literacy skills to students with physical and developmental disabilities. Improvements were reported for 37% of participants. However, summaries of the reviewed studies revealed that the existing literature base is perhaps best described as limited. Most notably the corpus of studies was limited in terms of research design; (61%) of the studies utilized a non-experimental research design. Additionally, the certainty of evidence for an intervention effect was rated as inconclusive for 12 of the 18 reviewed studies (see Table 1). Therefore, positive results must be interpreted with caution. Despite these issues, the reviewed studies do offer several relevant topics for consideration.

First, perhaps the most salient finding of this review is that students with significant physical and developmental disabilities who use aided AAC devices seem to benefit from receiving evidence-based literacy instruction in typical contexts (e.g., direct instruction, scaffolding, often during storybook reading). The majority (66% of participants) were diagnosed with multiple disabilities or genetic syndromes, but were also reported to have an awareness of basic print and symbolic representation prior to intervention. Many interventions were situated within the context of parent–child shared book reading, a strategy linked to language growth, emergent literacy skills, and reading achievement for preschoolers who are not yet independent readers (Bus et al. 1995). Past research has also shown that shared book reading is an essential instructional strategy used in elementary classrooms (Sturm et

al. 2006). Specifically, shared book reading may provide familiar, predictable routines for students with physical and developmental disabilities to communicate with conversational partners using aided AAC. With text adaptations (e.g., attached picture symbols) and activity modifications (e.g., the use of concrete objects related to the story), children with significant and multiple disabilities may derive greater benefit from shared book reading (Browder et al. 2008).

Second, this review presents preliminary evidence suggesting effective instruction may improve student performance in skills that can be especially challenging for nonverbal children: letter-sound correspondence, tasks that require phonemic awareness such as word segmentation for spelling, and word reading tasks. The challenge of providing instruction may exist in part because, in traditional literacy instruction, students frequently demonstrate their understanding of phonemic awareness through articulating the individual sounds in words, or through listening to the sounds, then orally producing a word (Eunice Kennedy Shriver, NICHD 2001), whereas students who use AAC require other means of practicing and communicating these concepts. The reviewed studies suggest improvements in phonemic awareness. However, phonemic awareness is difficult to measure in this population and accurate measures of phonemic awareness remain warranted, especially considering that phonemic awareness is an essential prerequisite for students to put phonemes together to form words.

Third, positive participant outcomes (i.e., high mean PND scores) appear to be related to the use of evidence-based systematic instructional procedures such as direct instruction, least to most prompting, and scaffolding of child communication. This is not surprising given that previous reading research has indicated that more explicit and systematic instruction, particularly in phonemic awareness, phonics, fluency, and comprehension strategy instruction, tends to improve reading outcomes (NICHD 2000; Wanzek and Vaughn 2007).

In regards to our second aim, to identify gaps in the literature, the results suggest several areas for future research. Foremost is the need for more research utilizing rigorous experimental designs. Researchers and clinicians may choose a non-experimental research design in part due to their flexibility and usability in clinical settings. For instance, researchers might utilize non-concurrent multiple baseline designs, because it is untenable to begin baseline assessment for all participants at once. In situations where experimental designs are a mismatch to participant or setting characteristics, there are potential methodologies that researchers might use to strengthen their chosen research design. For example, researchers utilizing non-concurrent multiple baseline designs might combine non-concurrent multiple baseline designs with true multiple baseline designs (cf, Harvey et al. 2004). Given the relative lack of rigorous experimental research evaluating literacy instruction for students with physical and developmental disabilities who use aided AAC, future research should focus on using such designs to evaluate existing, evidence-based literacy interventions with this population.

Second, the majority (56%) of studies reviewed here implemented multi-component interventions, so the contribution of individual instructional components to positive intervention effects is difficult to ascertain. Determining the most parsimonious and effective intervention package may be especially important given limited classroom resources (e.g., time and staff) that may be available for literacy

instruction in some educational settings (Koppenhaver and Yoder 1993; Mike 1995; Zascavage and Keefe 2004). Future research could conduct component analyses of multi-component literacy interventions to determine essential instructional strategies for teaching emergent literacy skills to this population.

Finally, the majority (73%) of studies utilized parents or researchers to deliver literacy instruction. Parents are obvious candidates for providing literacy instruction during naturally occurring home (e.g., reading the daily newspaper online, reading recipes during meal preparation, bedtime stories) and community routines (e.g., reading labels during grocery shopping). However, it would seem important to evaluate general education teachers' delivery of literacy instruction to students who use aided AAC users, because an increasing number of students with significant disabilities are fully included in general education classrooms. A related topic is the social validity of the instructional procedures reviewed here for use in a general education classroom. The majority of studies reported one-to-one instruction, which may be less feasible or desirable in general education settings where reading instruction typically occurs in small, ability-based groups of students, and peer interactions are valued. Future research should evaluate the implementation of literacy intervention in general education classrooms by general education teachers, and in a greater variety of instructional arrangements (e.g., small group).

In conclusion, this literature base highlights the importance of future research in the area of literacy instruction for students with physical and developmental disabilities who use AAC. Future research should evaluate the effects of evidence-based, systematic literacy instruction on a variety of targeted skills using rigorous experimental designs. Additionally, experimental analysis of the influence of specific intervention strategies on literacy skills may shed some light on the most efficacious literacy interventions for students with physical and developmental disabilities who use aided AAC.

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